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# THE CULTURE OF TOMATOES IN CALIFORNIA, WITH SPECIAL REFERENCE TO THEIR DISEASES

BY

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# THE CULTURE OF TOMATOES IN CALIFORNIA WITH SPECIAL REFERENCE TO THEIR DISEASES*

BY
STANLEY S. ROGERS

## THE ART OF HANDLING TOMATOES FROM SEED BED TO HARVEST

### Seed Selection

As the climatic conditions under which this crop is grown and the methods by which it is marketed are variable, no one type of tomato will be ideal in every tomato growing section of the United States or of this State.

In extremely hot localities, such as portions of the interior of California, a plant having a dense foliage is more desirable than in the cooler regions along the coast. Early maturing, highly colored fruit is more important for the early spring market than for the cannery. There are many local conditions which determine the most desirable qualities, so that each grower should study the type which is closest to his ideal. Before selecting the seeds it is very essential to have a written description of the ideal plant, giving in detail the character of the vine and fruit. When the work of selection is begun this description should be taken into the field, and those vines which correspond most closely to it should be marked, remembering that the *character of the plant as a whole should be considered and not the character of a few of the individual tomatoes.* Much better results will be obtained by selecting seed from a vine upon which a large percent of the tomatoes are uniformly good than from a vine bearing a few excellent tomatoes and the remainder below the average. In selecting for earli-

* The writer here expresses his appreciation of the assistance rendered by many of the tomato growers throughout the State, and especially of the services of Mr. Fred Davenpeck at San Jose, and Mr. William Hodges at San Leandro, both of the California Fruit Canners Association. Valuable assistance was also rendered by Dr. J. E. Coit in the preparation of the outline of this bulletin, and Mr. C. O. Smith by whom most of the photographs were taken.

ness it is not necessary to save seed from the first ripe tomatoes, but the vine should be marked so that seed can be saved from it later in the season when the fruit is worth less in the markets. The seed from each vine should be kept separate, carefully dried, numbered, and a detailed description made of the plant from which it comes. The following year, plant seed enough to grow 50 to 100 plants from each lot and set these plants in blocks and number the blocks. During the season more or less irregularity in the plants will be noted, some will be superior, while others will be inferior to the plant from which the seeds were obtained. Select seeds from these new plants in the manner employed the previous year. By repeating this method of selecting seed for a few years a fixed strain is developed which should be far superior to the original. After the second year of selection, it will pay the grower to plant his own seed, although the longer the selection is carried on the better will be the results. Much has already been accomplished along this line, securing increased yields and a better type of fruit and vine, for there are but few plants which respond so quickly to seed selection and crossing as the tomato.

### Seed Beds: Their Preparation, Planting and Care

There are three methods used in this state for growing tomato seedlings. Those who are raising tomatoes for the early spring markets usually grow their young plants in hot beds. The growers who depend upon the late summer or fall markets and upon the canneries for the consumption of their crop generally grow their young plants in cold frames, or in the open.

When the hot bed or cold frame is used the seed is sown in drills three to six inches apart, sowing four to six seeds to the inch and covering with one-eighth to one-quarter of an inch of sand. After the soil has been thoroughly watered, cover with burlap, cloth, or light canvas until the seedlings begin to break through the surface. When the seedlings have grown their true leaves, thin to a distance of three to five inches. The latter distance is preferable if they are not to be transplanted before setting in the field. Many growers sow the seed in flats and transplant to the hot bed or cold frame when the plants have grown their first true leaves. This method will produce much stronger and larger plants than if they are not transplanted before setting in the field, and it is strongly advocated.

When the crop is grown for the canneries or for the late fall market the seed is not usually planted until April. At this season the weather is so mild that the seedlings can be grown unprotected in the

open. In selecting the location for the seed bed only well drained, light soil, well sheltered from the cold winds should be used. The soil should first be put into as fine a condition as possible and the seed planted in rows two and one-half to three feet apart. This distance is necessary to enable the grower to irrigate, cultivate, and remove the plants with the least amount of work. Under certain conditions it will pay the grower to start the seed in flats and transplant the seedlings to the field, especially if the soil in the latter is heavy and difficult to pulverize.

*Watering the Young Plants.*—The method of watering the young plants has a large influence upon their growth and condition. Overwatering tends to produce weak or diseased plants while if the amount of water is insufficient the growth is seriously checked. The plants themselves are the best indicators when water is needed and it is always best to water liberally, rather than to apply a small amount often. Water in the morning so as to allow the surface of the ground and the tops of the plants to become dry before night. During cloudy or foggy weather do not water unless absolutely necessary. By varying the amount of water, the growth of the plants can be controlled to a large extent. Watering should be stopped a week or so before the seedlings are to be transplanted. This will aid in hardening them off and they will withstand transplanting much better than if their stems are full of sap. A few hours before the plants are taken up, the ground should be thoroughly watered so that the earth will adhere more readily to the roots. A week or ten days before the plants are to be pulled the cover of the hot bed or cold frame should be raised a little, increasing the opening from day to day and entirely removing the cover a few days before the plants are to be set in the field.

## FIELD CULTURE

*Soils Adapted to Tomato Growing.*—There is probably no other vegetable that will thrive on as many different kinds of soil as the tomato. When growing this crop for the early spring or late fall markets, a lighter soil is desirable than when growing the main canning crop. Probably the best soil, all things considered, is a light loam or silt underlaid at a depth of four to six feet by a clay loam. A soil of this character works, irrigates and drains easily and is warm in the early spring and late fall. In a soil which is too heavy and over rich in nitrogen the growth of plants often goes to vine at the expense of the fruit. A soil which is too light will produce small plants and a light crop.

*Preparation of the Fields.*—In preparing the land for planting, fall plowing as deep as possible is practised with good results by many of the leading tomato growers. This enables the soil to retain much of the winter rains and lessens the work in the spring. A few weeks before planting, the field should be replowed and thoroughly cultivated to kill the weeds. The surface should be pulverized and made into a fine mulch to conserve the moisture as much as possible. Just previous to planting, the field is marked off both ways to show the location of the plants. In fields which are to be irrigated, furrows are plowed and the plants are set in them so that the marker is used in only one direction. When planting in an orchard the cross marking is sometimes unnecessary as the planter can be guided by the rows of trees.

*Transplanting from Seed Bed to Field.*—A few hours before the plants are to be removed from the seed bed, the soil should be thoroughly saturated with water. The plants should be taken up in such a manner that their root systems are disturbed as little as possible, either by digging with a trowel or shovel, or pulling them up by grasping the stems. The first method is preferable, for the extra time involved is more than offset by the rapidity with which the plants begin to grow, due to the preservation of many small roots which would have been broken off by rough handling. The plants should be hauled immediately to the field and reset as soon as possible. Care should be taken not to expose the roots to the air, or allow them to dry out.

After the field has been put into the best possible tilth and marked off, it is ready for the plants. In the fields where it is possible to irrigate, the plants are usually set in the furrows by the aid of a dibble while the water is running down them. If the land is so uneven that there is danger of washing the earth from the roots, the plants should not be set until the water has run off. The depth to which the plants are set varies somewhat, according to their size and the character and condition of the soil, but they should be planted a few inches deeper than they were in the seed bed. In fields which are impossible to irrigate, the plants are set in holes made by a dibble and water is hauled onto the field, giving each plant enough to start it well. If the plants are too tall and slender it will pay to cut the tops back. After the field has been set for a week or ten days the plants should be examined and all those which have failed to start pulled up and others put in their places.

When growing tomatoes for the canneries and general market, the plants are usually set seven feet apart, in rows which are seven feet apart. When grown for the early spring market, the plants are usually

set closer together. The character of the soil has much to do with the proper spacing, as planting is closer on light sandy soil than on adobe. The variety to be grown should also be considered in this connection. Small vine varieties, such as Sparks Earliana, should be planted closer than rank growing varieties, such as the Stone or Trophy. The quantity of available water might also influence the proper spacing.

*Cultivation.*—Thorough and frequent cultivation when the plants are small will save a good deal of hand hoeing at the latter part of the season. Cultivation should commence as soon as possible after the field has been planted, and should be repeated as often as necessary to keep the soil friable and the growth of weeds down. The soil should always be thoroughly cultivated after each irrigation. If it is impossible to irrigate, much moisture can be retained in the soil by forming a fine mulch on the surface.

*Irrigation.*—The exact number of irrigations which a field should receive is dependent upon the character of the soil, climatic conditions, the season of year, care of the plants, and other minor factors. Enough water should be applied to keep the plants growing steadily; the soil should be wet each time to a depth of four to six feet. Over-irrigation will tend to produce growth of vine at the expense of the fruit, and is often the cause of blossom dropping and of soft, watery fruit. Enough water should be applied while the plants are growing so that it will not be necessary to irrigate after the crop has begun to ripen. The water should be run in furrows between the rows.

## HARVESTING

There is no other fruit or vegetable which can be so easily injured from careless handling as the tomato. From the time the fruit is picked until it is sold, all unnecessary handling should be avoided, for the skin is very easily broken. When picking, care should be taken to disturb the vines as little as possible, pulling off the fruit in such manner that the stems are left on the vines. It is better to pick into a box or pail rather than a basket. The most desirable degree of ripeness for the fruit when picked depends upon the proximity to the market. Much loss can be avoided if the over-ripe, wormy and other undesirable tomatoes are pulled off the vines, thrown in piles and burned on the field. The same care should be exercised whether picking for market or cannery, though the latter can use fruit coarser and riper than is desired for the market. Many pickers become careless, and the growers should examine as much of the fruit as possible before it has been hauled to the cannery.

*Packing for Long Distance Shipments.*—On account of the excellent opportunities for growing tomatoes to mature in the late fall and winter, in the many nearly frostless sections of the southern part of the State, there has developed a promising industry which is fast becoming one of California's most profitable enterprises. Since this winter crop is shipped as far as Boston, Canada, and New Orleans, the success of the industry depends largely upon the condition of the fruit when picked and the careful handling of it from the time it leaves the vines until it is sold in the markets. Fresh tomatoes are scarce in the east at this season, and this California product finds a ready sale providing it arrives in good condition.

After the fruit has been picked it is packed firmly in lug boxes, each holding about 35 pounds, hauled to the packing house as soon as possible, put on trucks, weighed, and carried to the sorting tables. Here each tomato is carefully examined, special attention being paid to the size, color, shape and firmness. Those which are up to the standard are wrapped in tissue paper and firmly packed in five pound baskets, four of which fill a crate. When a crate is packed, the cover is nailed on and it is loaded into a car. An average car holds about 700 crates. The fruit is packed in these baskets by women and as this careful sorting of the fruit means the success or failure of the business, the packers are very closely watched. A single green or over-ripe tomato can easily spoil the basket or even crate. No tomato which shows a bruise or soft spot is packed, for the skin will easily become broken and decay will soon start.

In order to handle this crop profitably, a thorough knowledge is needed of the conditions prevailing in the leading markets throughout the United States, and also of the supply which is ready for shipment on the western coast.

On this account, in each section in which a considerable acreage is planted to winter tomatoes, there has been formed an association composed of tomato growers. Each year this association elects officers which are generally among the leading growers in each community. These men look after the interests of the association as a whole, and of the individual growers. At the beginning of the season, each member is given a number, and the amount of fruit delivered throughout the season by him is kept on the books of the association. Their selling agent deals with the association as a unit and not with the individual growers. This works favorably, as all the fruit which is accepted for shipment by the association must be up to the same standard. The final destination of a car is generally known before it leaves the packing house. The net proceeds from the sale of the car of tomatoes are

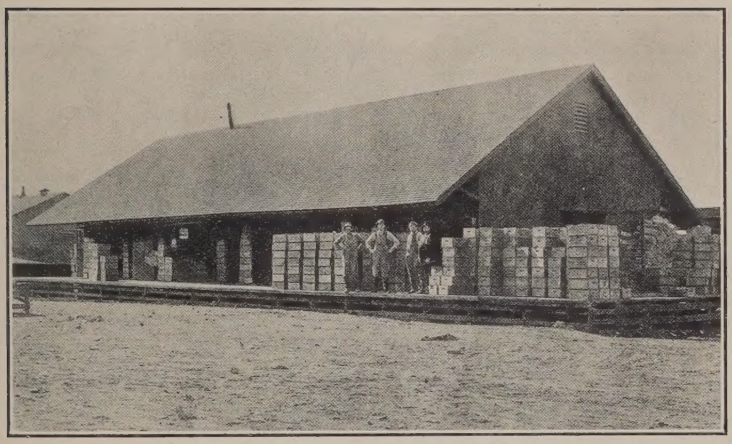

Fig. 1.—Tomato packing house: The tomatoes are taken from the field directly to these houses where they are weighed, carefully sorted and packed in crates for shipment.

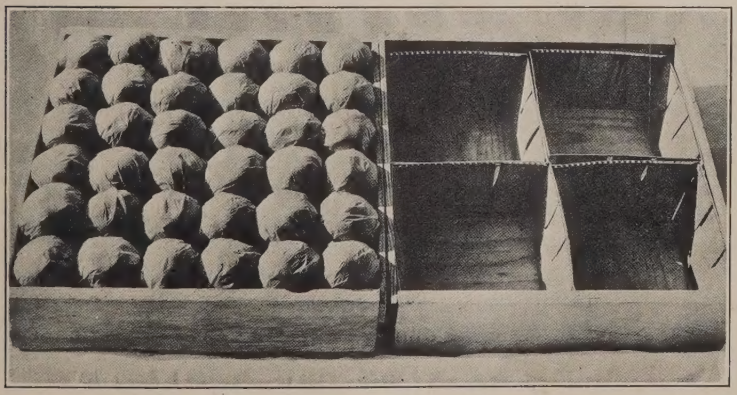

Fig. 2.—Empty crate and one packed for long distance shipment: Each tomato is wrapped and it is very important that they should be free from injuries and imperfections and uniform, and that they be firmly packed.

divided pro rata among the growers whose fruit it contained. As the tomatoes must be of a very high quality for shipping there are many which are undesirable and yet are perfectly sound. These are sold to a cannery and each contributing grower is given due credit.

## Market Requirements

It has been said that Americans eat with their eyes and the tomato market illustrates this. In other words, a tomato which is highly colored and well shaped will outsell one which has rather a dull color and is not quite as symmetrical, even if the latter is much superior in flavor and solid meat. In growing tomatoes for shipment it is always best to study the demands of the market and meet them as nearly as possible. The requirements of the various markets are somewhat different, but in California the demand is for a smooth, solid, medium sized, highly colored, round tomato, which contains as little water and few seeds as possible.

The ideal canning tomato varies little from the kind best suited for the market, but the most desirable size is a little larger.

## Cost of Production and Profits

It is impossible to give the exact profits which should be realized from growing this crop, for they are extremely variable and depend upon the grower and his local conditions. The cost of producing an acre of tomatoes ranges from $25 to $45, depending largely upon the soil, location, season of the year, the grower, and other factors. The average cost would be from $32 to $40 per acre not including the hauling to market.

The prices received vary with the season. Generally for the local markets the spring and early winter crops command the highest prices. Growers who market their crops in the early spring often realize a gross profit of from $75 to $150 per acre. Those who harvest the crop during the late spring or summer usually get a gross profit of from $35 to $75 per acre, while those who are growing the late fall crop get between $100 and $200, gross, per acre. These figures represent a very general average, for many of the more skilled growers exceed these estimates. The average yield of tomatoes grown for the canneries is about 10 tons per acre, although the yields obtained by many of the more successful growers, are as high as 20 to 25 tons per acre.

## VARIETIES

On account of the extremely wide range in climatic conditions to be found in this State it is possible to grow any of the many tomatoes listed in the seed catalogues.

The varieties which, at present, are most popular in various tomato growing sections of this State are Stone, Trophy, Sparks Earliana, and a few local selections.

*Stone.*—The general favorite on the market. In southern California it is grown both for the market and canneries, while in Alameda and Santa Clara Counties it is grown mostly for the former. Vine growth is luxuriant, so that this variety is especially desirable where climatic conditions require the fruit to be well shaded. The vines are heavy bearers when well cared for and given sufficient water. The fruit is highly colored, smooth, firm, and especially desirable for long distance shipment. Although this is a very popular variety there is room for improvement through careful seed selection. It is not an early bearer.

*Trophy.*—Grown in San Francisco bay region mainly for canning purposes. The vine is a vigorous grower and heavy bearer. The fruit is large, but too rough for sale on the markets, well colored, but not as firm as the Stone. This variety has deteriorated in quality, due largely to carelessness in collecting seed.

*Sparks Earliana.*—Grown only for the market and valuable mainly on account of its earliness in maturing. Vine growth is much smaller than in either of the preceding varieties. The fruit sunburns badly and is not a very good shipper, but is well colored, medium sized and round. It is highly recommended for the early spring markets.

*Local Varieties.*—There are growers in this State who save their own seed from year to year, and in several of the larger tomato growing sections a few local selections have been made. Among the most important and desirable are the Kennedy and the San Filipo which are much alike and are used extensively in Santa Clara County for the canning crop. These selections are proving to be much more satisfactory than any sold by the various seed companies. The vines are large and bear a heavy crop of well colored, well shaped, and firm fruit. They have met with such favor that a few of the canneries prefer them and carry this seed in stock for the growers. The benefits to be derived from seed selection are taken up in detail on pages 591 and 592.

# DISEASES OF THE TOMATO

## Damping Off in Seed Bed

*Cause.*—This disease is common in the seed beds and some years occasions large losses. Damping off is due to one or more fungi which attack the tender seedlings at the surface of the ground causing the tops to fall. Upon microscopic examination, the fungi *Rhizoctonia, Fusarium, Botrytis* and *Sclerotinia* have been found on the affected plants. The disease generally affects the plants in various portions of the seed bed, and sometimes these infected areas enlarge very rapidly until the whole bed becomes worthless.

*Control.*—As the spores of the fungi which cause damping off are capable of living in the soil from one year to another the earth used for the seed bed should be changed each season. Water the plants, if possible, only on sunny days, preferably in the morning, so as to allow the tops and the surface of the soil to dry rapidly. Stir the earth after each watering. Avoid over-crowding the plants. A suitable covering should be made to protect the bed from rain and fog. Ventilate the seed bed as well as possible and keep the plants thrifty. When they are commencing to grow their true leaves, spray with Bordeaux mixture, using 3 pounds of bluestone and 4 pounds of lime to 50 gallons of water. This will not only help to keep the damping off in check but will keep the plants free from attacks of other fungi. If this disease has already started, spray immediately with Bordeaux mixture, scatter flowers of sulphur around the plants and dry out the earth as much as possible without seriously injuring them. If the disease is still uncontrolled let the bed go and start a new one, using clean soil. ( Fig. 3.)

## Failure to Set Fruit

*Cause.*—Tomato growers are often troubled by the blossoms dropping from the vines and although the plants grow luxuriantly, very little fruit sets. This infertile condition of the blossoms is generally due either to unfavorable climatic conditions at the time the blossoms are forming, or to the character of the soil. Any weather condition, such as rain, cold or heavy fog, which interferes with the scattering of the pollen seriously affects the setting of the fruit. If the blossoms open during extremely hot, dry weather they are liable to burn.

Another common cause for the failure to set fruit is an over-supply of nitrogen in the soil. This may be a natural condition, or may be

due to heavy applications of stable manure or commercial nitrogenous fertilizers. Over-irrigation when the blossoms are forming often causes them to drop.

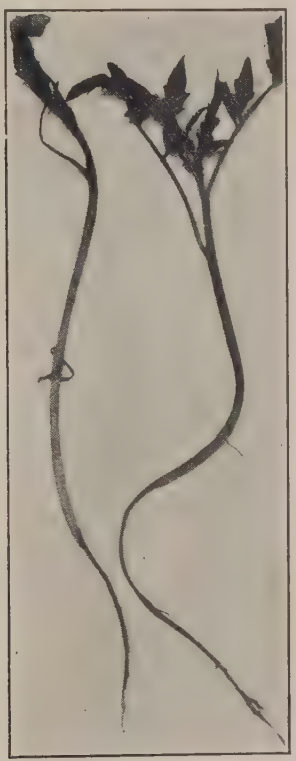

Fig. 3.—Damping off of tomato seedlings: This disease may be caused by several fungi which are particularly liable to become active when there is an excess of moisture.

*Control.*—If unfavorable weather conditions cause the blossoms to fall, the time of planting might be changed. Unless the soil is very deficient in nitrogen it is generally better to apply stable manure at least one year before growing tomatoes. Soil which is naturally too rich in nitrogen for the fruit to set well should be avoided. Do not over-irrigate when the blossoms are opening.

## Late or Winter Blight

The cause and control of this disease were explained and the methods for its control under California conditions were demonstrated in 1906 by Professor R. E. Smith, whose report was published as Bulletin No. 175 of this Station. This bulletin has been exhausted, and, as the disease is still prevalent, it seems advisable to give it more than passing mention.

Late blight occurs chiefly in the fall after the seasonal rains have commenced and is much more prevalent along the Coast than in the interior of the State. During rainy, or continuously foggy weather, it has also been found occasionally in the seed beds.

*Appearance.*—This disease affects all parts of the plant above ground, making them look as if killed by frost. On the affected leaves, branches, and stalks there can be seen small, blackened areas which rapidly grow in size and number under favorable conditions, until the whole plant soon blackens and dies. On the fruit appear dark spots which also closely resemble the results of frost. These spots increase in size and number, causing the tomato to decay very rapidly. Fruit in all stages of ripening is affected, and the diseased spots continue to develop even after an infected tomato is picked. Fruit that looks perfectly healthy when picked from an affected vine will often develop this blight after being packed.

*Cause.*—The late blight is caused by the fungus *Phytopthora infestans* (Mont.) DeBy, which cannot develop without an abundance of moisture. Before the spots blacken, the fungus appears as a delicate white mildew on the surface of the affected fruit or vine. It consists of masses of microscopic threads which grow into the tissue of the fruit or branch, producing the rot, and also send out branches into the air. On the ends of these aerial filaments are formed the spores of the fungus by which the disease is spread. The spores soon drop off and are scattered by various agencies, such as moisture and wind. The contents of these spores, or sporangia as they are called, divides into several small swarm spores, as shown in Fig. 4, each one of which is supplied with two tail-like appendages called cilia by which it is able to move about in a drop of water. When the swarm spores are ready to escape, the spore opens up and they come out, swimming about for a short time in the surrounding water. Finally they come to rest, sprout, and if they are situated on a tomato plant and provided with plenty of moisture, the filaments grow into the tissue and a new infection is started.

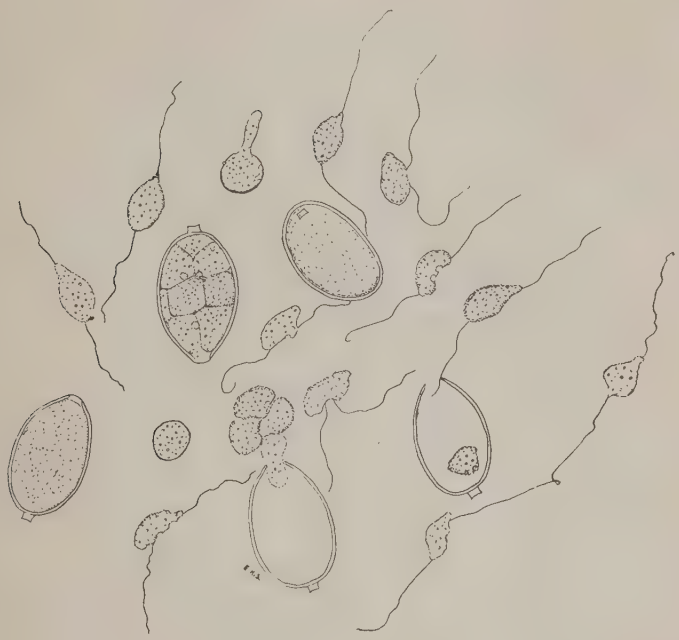

Fig. 4.—Spores or sporangia of *Phytophthora* showing the formation and subsequent germination of swarm spores. The large oval body at the left is the spore or sporangium, just above and to the right of this is a spore showing the contents dividing into swarm spores, below this the swarm spores are shown escaping to swim about. In the center at the top is shown a swarm spore which has rounded up, lost its cilia, and is germinating by sending out a tube.

*Control.*—It has been demonstrated by experiments carried on by this Station and by growers that it is possible to keep this disease in check by spraying immediately after each rain storm. Various spraying materials have been used, but the best results were obtained with Bordeaux mixture, using 5 pounds of blue stone and 5 pounds of lime to each 50 gallons of water. It will not usually be found necessary to spray until after the rains have commenced. Fruit which has become spotted by the spray can be cleaned by wiping lightly with a dry cloth. (Figs. 5 and 6.)

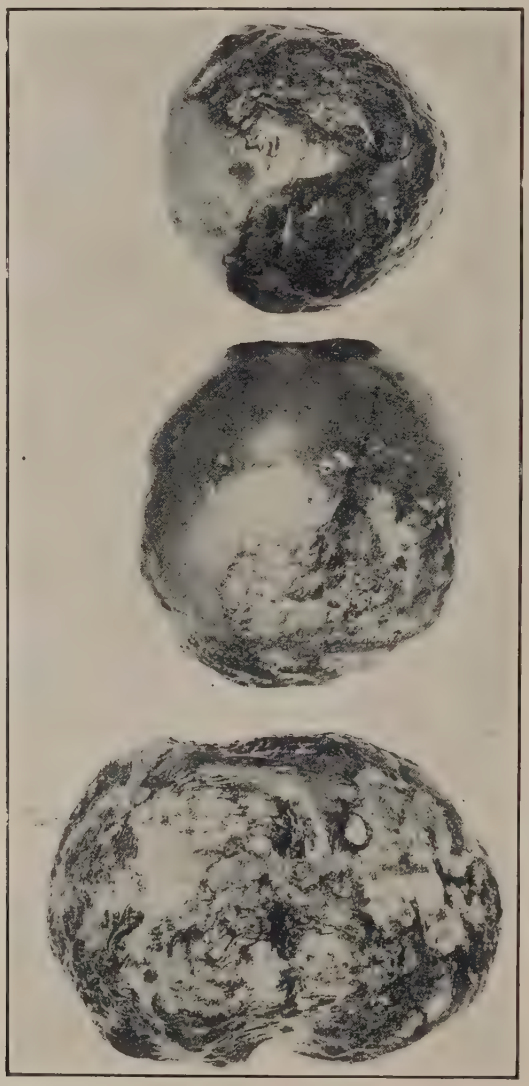

Fig. 5.—Winter blight of tomato fruit: A soft, rapid decay is produced.

Fig. 6.—Winter blight of tomato leaf: Large brown spots form and the leaves wither rapidly.

## BLOSSOM END ROT

*Appearance.*—This disease is common in the various tomato growing sections of the State and is often the cause of large losses. The blossom end rot, or, as it is sometimes called, point rot, occurs only on the blossom end of the fruit, causing a brownish circular spot to appear, which later becomes black. As the infection is superficial the tissue underlying the affected area is uninjured. The spot soon ceases to spread and in a few days appears to be sunken, due to the growth of the surrounding healthy tissue. The size of the spots varies from small to very large, some affecting the greater part of the tomato (fig. 7).

*Cause.*—The direct cause of this disease seems to be very obscure and has been the subject of a great deal of controversy.

A publication by Dr. George E. Stone,[1] issued in 1911, gives an account of work on this disease carried on for sixteen years. This investigation indicates that bacteria are its active cause, while the fungi, which are occasionally present, are of only secondary importance. The author also states that improper moisture conditions tend to make the tomatoes coarse, ill shaped, and fissured at the blossom end, thus offering favorable conditions for the entrance of the bacteria. Other conditions, such as insufficient atmospheric moisture and too much sunlight, also favor the disease.

Miss E. H. Smith, in working with Dr. Stone on this problem in 1905,[2] found that a species of the fungus *Fusarium* might also be responsible for the rot in some cases. From inoculation work with other bacteria than the one isolated, she came to the conclusion that more than one organism may be instrumental in producing blossom end rots which are very similar in appearance.

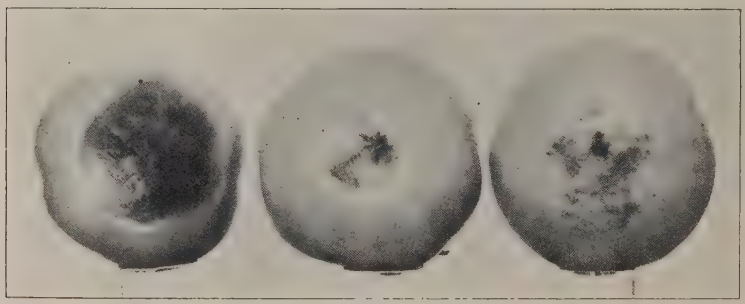

Fig. 7.—Tomatoes showing blossom end rot: The cause of this disease is somewhat obscure, but thus far remedial measures consist in giving good care and not allowing the plants to suffer for lack of water.

In 1900 F. S. Earle[3] and William Stuart[4] both reported a blossom end rot of the tomato from which they isolated bacteria capable of producing rot through artificial infection. The presence of the fungi *Macrosporium* and *Fusarium* has been noted by several investigators, but bacteria seem to have been found most generally in connection with this disease.

Under California conditions the trouble seems to be more physiological than bacterial or fungoid, and its appearance is dependent

[1] Bulletin 138, Mass. Agric. Exp. Sta.

[2] Mass. Agric. Exp. Sta. Technical Bulletin No. 3.

[3] Ala. Exp. Sta. Bulletin No. 108, 1900, p. 19.

[4] Ind. Agric. Exp. Sta., 13th Annual Report, p. 23.

almost wholly upon the conditions under which the crop is growing and especially those pertaining to the quantity of moisture. The blossom end rot occurs mainly in those fields in which the plants are without sufficient moisture throughout the entire season, especially if the atmosphere is dry and hot. Another condition which favors the appearance of this disease is that in which the field is allowed to become too dry between irrigations.

*Control.*—Keep the plants growing steadily. Irrigate at regular intervals, putting on a sufficient amount each time to allow the water to reach the feeding roots. Cultivate thoroughly after each irrigation.

## Root Knot

Occasionally when tomatoes are planted in sandy soil, many of the vines will suddenly stop growing, turn a yellowish color, and slowly die. Upon examining the leaves, stems, or fruit, no unnatural spots can usually be detected and the grower is led to believe that the soil is deficient in plant food.

*Cause.*—Upon pulling up these plants, many galls or knots will often be found on their roots. These swellings are formed by the invasion of nematode worms (*Heterodera radicicola* (Greef) Mül.) into the tissues of the roots. These minute worms which are the cause of the unhealthy condition of the plants are small, whitish, pear-shaped bodies about the size of a pin point and can be seen by cutting into the galls. The worms affect the plant in four ways: (1) The ducts are deranged, making it impossible for the food and water to pass to the upper portions of the plant. (2) The affected roots often crack, allowing the various pathogenic soil fungi and bacteria to enter, causing decay. (3) The worms feed upon the substances of the plant. (4) The plant, being weakened, is more susceptible to attacks from fungi or bacteria.

Plants which are attacked by nematode worms usually die slowly, the length of time being dependent upon the number and size of the affected roots. If only a few of the roots are injured, the plants will often get sufficient nourishment to live throughout the season.

*Control.*—Tomato plants may become infected in the seed bed or in the field, and, as these worms live in the earth from year to year, the question of control is one which deals directly with the soil. When removing the plants from the seed bed, they should be carefully examined, and all which are diseased should be burned, for if transplanted these affected plants serve as centers by which the whole field may become infested. (Figs. 8 and 9.)

Fig. 8.—Roots of tomato plants affected by nematode worms: The diseased roots are at first plump and light colored and very succulent, but they early commence to wither and decay.

Fig. 9.—Showing advanced stage of nematode infection: The root in the center is still fresh and succulent, while that at the right is decayed and much disorganized.

The soil used for seed beds should be changed every year, and should always be taken from a field which is known to be free from these worms. When a field becomes infested there are three methods of control which may be employed, the choice depending largely upon the local conditions. (1) Desiccation: thoroughly drying out the soil will control these worms. The climate of California, on account of the long dry summers, is especially adapted to this treatment. (2) Planting a crop which is very susceptible to nematode infection and plowing it up and burning it after the worms have deposited their eggs but before they have hatched. (3) Growing a crop upon which these worms cannot feed.

### Anthracnose or Ripe Rot

*Appearance.*—This disease is found occasionally on ripe tomatoes, but the loss from it is very small. Infected fruit is spotted with black circular areas, generally on the shady side of the tomato. The spot is similar in appearance to that of the blossom end rot, though it affects the fruit at no special place.

*Cause.*—Several fungi have been found closely associated with this rot, and its exact nature is not yet fully understood.

*Control.*—Burn all affected fruit. If the disease becomes serious, spray immediately with Bordeaux mixture, using 5 pounds of blue stone and 6 pounds of lime to 50 gallons of water.

### Leaf Spot

This disease is found occasionally in the seed beds in California, but owing to the climatic conditions has never been troublesome in the fields. It has, however, been very serious in the eastern and southern parts of the United States.

*Cause and Appearance.*—This disease is caused by a fungus, *Septoria lycopersici* Speg., which attacks the leaves, causing the appearance of numerous oval or circular spots about the size of a pin head. The margin of these spots is dark and the interior light in color. Scattered through this lighter colored area are small, black specks or masses, which are the pycnidia, or fruiting bodies of the fungus, containing the spores. The lower leaves are the first to become infected, and, if seriously diseased, turn yellow and die.

*Control.*—Spray the seed beds with Bordeaux mixture. If the plants are less than 6 inches in height, use 3 pounds of blue stone and 4 pounds of lime to 50 gallons of water. When the plants are

larger, use 4 pounds of blue stone and 5 pounds of lime to 50 gallons of water. The spray should be applied before the disease appears, or as soon after as possible. Repeat the spraying as often as necessary to keep the plants well covered. When removing the plants from the seed bed, discard and burn all which are badly diseased, and pull off all infected leaves from those to be transplanted to the field.

If the disease is troublesome in the field, spray with Bordeaux mixture, using 5 pounds of blue stone, and 6 pounds of lime to 50 gallons of water.

Fig. 10.—Leaf Spot (*Septoria lycopersici*): This disease is occasionally troublesome in California, especially in seed beds.

### Sunburn

Occasionally, in the southern and interior portions of the state, the tomatoes are burned by the sun while they are on the vines, as a result of which they become pale yellow in color and are rendered unfit for food.

*Control.*—In the sections in which there is danger from sunburn a variety of tomato having a dense foliage should be grown. Plant as early in the season as possible, so that the vines will attain their growth before the approach of hot weather. Spraying will do no good.

### Summer Blight or Wilt

This disease has been present for a number of years in many of the tomato fields throughout the State and has been the cause of enormous losses. Since 1905 investigations as to its cause and control have been carried on by this Experiment Station, and a bulletin will probably be published in the near future reporting this work in detail.

*Description of a Field Affected by Wilt.*—When a field has become affected by wilt, diseased plants can be seen scattered here and there, the number increasing generally until a large part of the crop has been ruined. In other fields the disease makes very slow progress,

Fig. 11.—Tomato field seriously affected by wilt: Plants are killed in a promiscuous manner and in this picture only a few are left in the foreground. The disease is very obscure and has probably not been understood.

Fig. 12.—Tomato plant seriously affected by wilt: A plant with this disease slowly withers and dies without any insect or fungus being present to which the trouble can be ascribed.

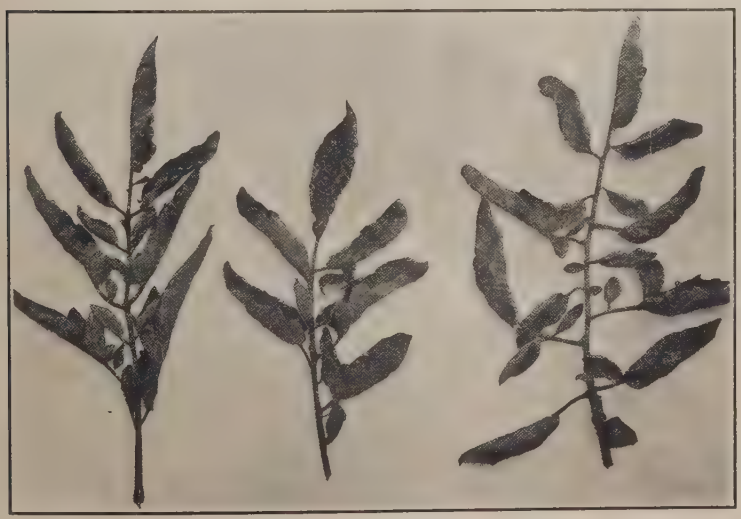

Fig. 13.—Leaves of wilt infected plant showing characteristic roll: This and the purple color of the veins are the early symptoms of the disease.

affecting only a few plants throughout the entire season. When a plant becomes diseased, its condition has no effect on others. A diseased plant is oftentimes surrounded by perfectly healthy vines, and in many cases large tomato fields contain only one plant which has been affected by wilt. From a distance a badly affected field resembles one in which the stand of plants is very poor, but upon closer examination these apparently vacant spaces will be found to contain dead plants. Figure 11 shows a field with many plants dead and many of the remaining vines diseased.

*Description of a Plant Affected by Wilt.*—When a plant first becomes affected by wilt, growth stops, the color becomes unhealthy like that of a plant which is getting insufficient nourishment. The leaves soon roll upward, become purple, and often turn a sickly yellowish color. Upon closer examination it is found that this purpling is in the veins of the leaves and is more noticeable on the under surface. In rare cases one-half of the leaf from the vein to the edge will be purple and the other will remain apparently normal. All the leaves show the disease at about the same time. If a diseased branch be cut from a plant the leaves will retain their purple color and will not droop as soon as the leaves of a detached healthy branch. Although this purple coloring in the veins of the leaves is a characteristic of this disease it seems to be secondary; for in the autumn when the nights are cold and the days are warm this purple color can often be found in those leaves of healthy plants which have their under surfaces exposed to the sun. In the spring and summer, this purple color is unnatural and during these seasons may be considered as showing an abnormal condition of the plants. The central cylinder of an affected plant often completely dries up leaving a hollow core. If the top of one of these plants be cut off at the ground it will bleed very little, showing a scarcity of sap.

After a plant has been killed by this disease the main branches remain in their normal positions. The leaves and extremities of the stems and laterals finally droop and dry up, sometimes remaining in this position until the end of the season. When a plant is killed early in its growth, the leaves are often blown away by the wind. No unnatural spots on the leaves, stems, or fruit, have been seen in connection with this disease. The roots of a plant affected by the wilt appear to be normal.

The following brief observations are given at this time with the hope that they will be of some value to the grower. Our experiments have proved that the occurrence or the amount of wilt is not influenced by rotation of crops, character of the soil, amount of soil moisture,

preparation of the soil, or care of the plants in the seed bed or in the field. During this investigation, tomato plants from twelve varieties were grown, but all were affected about alike. The varieties tested were Stone, Trophy, Sparks Earliana, Atlantic Prize, Fifty Days, The Earliest, June Pink, Earliest Pink, Greater Baltimore, Five Million Dollar, Ponderosa, and two local varieties.

There is a close relation between the appearance of this disease and the season of planting. Plants which are set in the fields during early spring are much more liable to become affected than those which are planted after the middle of June. The date of the first appearance of the wilt is dependent to a large extent upon the temperature. It generally begins to appear soon after the first hot weather of the spring.

## THE HISTORY OF THE TOMATO INDUSTRY

The tomato,[5] or love apple, originated in Peru and was first named by botanists in the sixteenth century.

In Europe the tomato[6] first came into general use in Italy and Spain where it was used during the 17th century for soups and salads. In Japan and China it has been cultivated only during the past century. It was first mentioned as being grown in America for culinary use about 1781. Mr. W. W. Tracy found tomatoes first regularly quoted in the American markets at New Orleans in 1812. The seeds were first offered for sale as those of an edible vegetable by seedsmen in 1818.

Up to the 19th century the tomato was popularly regarded as poisonous and this opinion was held by many as late as 1829. After 1835 the demand for it increased until, at the present time, tomatoes are considered to be one of the most healthful vegetables grown.

*Growth of the Tomato Industry in the United States.*—During the past fifty years the growth of the tomato industry in the United States has been phenomenal, and the amount of land devoted to it has increased from a few home gardens to nearly a half million acres. The amount of tomatoes canned in the United States has increased from 3,000,000 cases (a case contains 24 cans) in 1887 to over 13,000,000 cases in 1907.[7] From 1900 to 1906 the average yearly consumption of tomatoes in the United States was approximately 9,000,000

[5] Alphonse De Candolle—Origin of Cultivated Plants, pp. 290–291.

[6] The dates mentioned in this and the following paragraph were taken from W. W. Tracy's book entitled "Tomato Culture," pp. 16–19.

[7] California Fruit Grower, December 11, 1909, p. 63.

cases.[8] During the season of 1907 there were 13,467,476 cases of tomatoes packed in the United States.[9] In the year 1908 the pack was 11,479,000 cases and about 8,000,000 cases in 1910.[10] During the season of 1911 the output of canned tomatoes in the United States was about 9,850,000.[11]

Aside from the tomatoes grown for the canneries, there is an enormous acreage devoted to growing tomatoes for the markets throughout the United States and Canada.

*The Tomato Industry in California.*—Tomato growing in this State has been an important industry for many years. The long season of continuous moderate weather through which this crop can grow, makes it especially profitable. There is a much larger acreage devoted to growing tomatoes for the canneries than for the markets. During the season of 1906 there were over 1,000,000 cases of tomatoes packed in this State, which, according to the figures compiled by the American Grocer, made California rank as the third state in the Union in the amount of canned tomatoes produced.[12] In 1907 California stood second with a pack of 1,283,099 cases. This was the largest pack ever put up in California up to that time.[13]

The tomato pack in California during the season of 1911 was 1,515,450 cases,[14] and was the largest amount of tomatoes ever packed in this State. It has been estimated that 7,200 acres of tomatoes were grown during the season of 1911 for the canneries in the State.

*The Fresh Tomato Industry.*—The following account of the status of the Fresh Tomato Industry of California was written by Mr. H. S. Hazeltine, of the California Vegetable Union at our request:

"Tomatoes were first shipped out of California in small lots, by express, about the year 1900, but little progress was made in the industry until the California Vegetable Union began to ship them by freight in mixed cars with other vegetables, as the local express charges were so exorbitant that there was little left for the grower when shipping in that way. The freight shipments enabled us to deliver the tomatoes in eastern markets at such a figure that the people in average circumstances could afford to buy them. As a consequence a demand was developed all over the United States and Canada, and

[8] California Fruit Grower, December 22, 1906, p. 21.
[9] *Ibid.*, December 19, 1908, p. 71.
[10] *Ibid.*, December 24, 1910, p. 12.
[11] *Ibid.*, January 27, 1912, p. 12.
[12] *Ibid.*, December 14, 1907, p. 19.
[13] *Ibid.*, December 19, 1908, p. 71.
[14] *Ibid.*, March 23, 1912, p. 6.

in 1905 car lots were shipped to the larger markets such as New York, Philadelphia, Boston, Chicago, Kansas City, and New Orleans. Now, cities with a population of 100,000 throughout the United States and Canada are buying in carload lots, and the demand is increasing yearly at the same rate as for other commodities, or perhaps faster, since the tomato is a very popular fruit or vegetable, which ever you may choose to term it. The shipments out of the state now amount to about 300 carloads each season. Shipments begin about the 15th of September and increase as the tomatoes are destroyed by frost in the East, which is usually about October 1st. Shipments continue until the crop is destroyed by rains or frost in California, usually about the middle of December. The market is always strong at the close of the season, and it is to be regretted that a frostless locality could not be found in California to take care of this demand throughout the winter, but such a locality has not been found yet; therefore we are obliged to draw our supplies from Mexico during mid-winter.

A carload of tomatoes contains about 700 four-basket crates of 25 pounds each, and brings an average of about forty cents a crate net to the grower. The average planting each year in California for eastern shipment is about 2000 acres. The average yield per acre during the shipping season of three months, is about four tons.

The tomato industry of California is now on a sound basis both from a commercial and financial standpoint. The California tomato is the best produced in the country and is in great favor with the eastern trade and consumer. It is considered a very profitable crop by the growers and is ranked as one of California's staple products at the present time, with a splendid future before it as the western territory develops, since we have little or no competition from any tomato growing section west of the Missouri River."

## STATION PUBLICATIONS AVAILABLE FOR DISTRIBUTION

### REPORTS

1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.
1902. Report of the Agricultural Experiment Station for 1898–1901.
1903. Report of the Agricultural Experiment Station for 1901–03.
1904. Twenty-second Report of the Agricultural Experiment Station for 1903–04.

### BULLETINS

No. 128. Nature, Value, and Utilization of Alkali Lands, and Tolerance of Alkali. (Revised and Reprinted, 1905.)
133. Tolerance of Alkali by Various Cultures.
147. Culture Work of the Sub-stations.
164. Poultry Feeding and Proprietary Foods.
167. Manufacture of Dry Wines in Hot Countries.
168. Observations on Some Vine Diseases in Sonoma County.
169. Tolerance of the Sugar Beet for Alkali.
170. Studies in Grasshopper Control.
171. Commercial Fertilizers. (June 30, 1905.)
174. A New Wine-cooling Machine.
177. A New Method of Making Dry Red Wine.
178. Mosquito Control.
179. Commercial Fertilizers. (June, 1906.)
181. The Selection of Seed-Wheat.
182. Analyses of Paris Green and Lead Arsenate. Proposed Insecticide Law.
183. The California Tussock-moth.
184. Report of the Plant Pathologist to July 1, 1906.
185. Report of Progress in Cereal Investigations.
186. The Oidium of the Vine.
187. Commercial Fertilizers. (January, 1907.)
188. Lining of Ditches and Reservoirs to Prevent Seepage Losses.
189. Commercial Fertilizers. (June, 1907.)
192. Insects Injurious to the Vine in California.
194. Commercial Fertilizers. (Dec., 1907.)
195. The California Grape Rootworm.
197. Grape Culture in California; Improved Methods of Wine-making; Yeast from California Grapes.
198. The Grape Leaf-Hopper.
199. Bovine Tuberculosis.
No. 201. Commercial Fertilizers. (June, 1908.)
202. Commercial Fertilizers. (December, 1908.)
203. Report of the Plant Pathologist to July 1, 1909.)
204. The Dairy Cow's Record and the Stable.
205. Commercial Fertilizers. (December, 1909.)
206. Commercial Fertilizers. (June, 1910.)
207. The Control of the Argentine Ant.
208. The Late Blight of Celery.
209. The Cream Supply.
210. Imperial Valley Settlers' Crop Manual.
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234. Red Spiders and Mites of Citrus Trees.
235. Further Proof of the Cause and Infectiousness of Crown Gall.
236. The Economic Value of the Western Meadowlark in California.
237. Pork Production under California Conditions.

## CIRCULARS

No. 1. Texas Fever.
9. Asparagus Rust.
29. Preliminary Announcement Concerning Instruction in Practical Agriculture upon the University Farm, Davis, Cal.
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